contracted with the Admiralty for a 31-knot torpedo-boat destroyer, the *Viper* (Fig. 2), which is of the same dimensions as the usual 30-knot vessels of this class, viz. 210 feet length, 21 feet beam, and about 350 tons displacement, but with machinery of much greater power than usual in vessels of this size; they also contracted with Sir W. G. Armstrong, Whitworth and Co. for machinery for one of their torpedo-boat destroyers.

The turbine engines of these vessels are similar to those of the *Turbinia*, but are in duplicate, and consist of two distinct sets of engines on each side of the vessel. There are four screw shafts in all, entirely independent of each other, the two on each side being driven by one high and one low-pressure turbine respectively of about equal power; the two low-pressure turbines drive the two inner shafts, and to each a small reversing turbine is also permanently coupled, and revolves idly with them when going ahead. The screw shafts are carried by brackets as usual, and two propellers are placed on each shaft, the foremost in each case having a slightly lesser pitch than the after one. The thrust from the screw shafts is entirely balanced by the steam acting on the turbines, so that there is extremely little friction.

The boilers, auxiliary machinery and condensers are of the usual type in such vessels, but their size is somewhat increased to meet the much larger horse-power to be developed, and to compensate for the lesser weight of the main engines, shafting, propellers, as well as the lighter structure of the engine beds. The boilers are of the Yarrow type, with a total heating surface of 15,000 square feet, and grate surface of 272 square feet, and the condensers have a cooling surface of 8000 square feet. The hull and all fittings are of the usual design.

Let us consider the machinery on one side of the vessel only: the steam from the boilers is admitted directly through a regulating valve to the high-pressure turbine driving one shaft, it then passes to the adjacent low-pressure turbine, driving its shaft independently, thence it flows to the condenser, and both the shafts then drive the vessel ahead; the reversing turbine revolves with the low-pressure shaft, and being permanently connected with the vacuum of the condenser no appreciable resistance is offered to its motion under these conditions. To go astern the ahead steam valve is closed and the astern steam valve opened, admitting the steam from the boilers to the reversing turbine, and reversing the direction of rotation of the inner screw shaft.

On the other side of the vessel the arrangement is the same, and it will be seen that she can be manœuvred as an ordinary twin-screw vessel, and with great facility and quickness.

On her second preliminary trial about three weeks ago, the mean speed of four consecutive runs on the measured mile reached 34·8 knots, and the fastest run was at the speed of 35·503 knots, which is believed to be considerably beyond the recorded speed of any vessel hitherto built. The vessel was scarcely completed at the time of this trial, and it is anticipated that still higher speeds will be realised on subsequent and official trials. The speed of 35·5 knots, or nearly 41 statute miles, represents about 11,000 indicated horse-power in a vessel of 350 tons displacement, as compared with 6000 to 6500 developed in the 30-knot destroyers of similar dimensions and 310 tons displacement.

At all speeds there was very little vibration. Her speed astern is guaranteed to be 15½ knots.

The *Viper* has surpassed the *Turbinia* in speed, and is at the present time the fastest vessel afloat.

In regard to the general application of turbine machinery to large ships, the conditions appear to be more favourable in the faster class of vessels, such as cross-Channel boats, fast passenger vessels, liners, cruisers and battleships; in all such vessels the reduction in weight of machinery, and economy in the consumption of coal per horse-power, are important factors; in some the absence of vibration is a question of first importance, as affecting the comfort of passengers, and, in the case of ships of war, permitting of greater accuracy in sighting of the guns.

The model exhibited represents a proposed cross-Channel boat for the Dover and Calais or Newhaven and Dieppe routes. She is 270 feet length, 33 feet beam, 1000 tons displacement, and 8 feet 6 inches draught of water. She has spacious accommodation for 600 passengers, and with machinery developing 18,000 horse-power would have a sea speed of about 30 knots as compared with the speed of 19 to 22 knots of the present vessels of similar size and accommodation.

It is perhaps interesting to examine the possibilities of speed that might be attained in a special unarmoured cruiser, a magnified torpedo-boat destroyer of light build, with scanty accommodation for her large crew, but equipped with an armament of light guns and torpedoes. Let us assume that her dimensions are about double those of the 30-knot destroyers, or of the *Viper*, with plates of double the thickness, and specially strengthened to correspond with the increased size and speed, length 420 feet, beam 42 feet, maximum draught 14 feet, displacement 2800 tons, indicated horse-power 80,000, there would be two tiers of water-tube express boilers, these, the engines and coal bunkers, would occupy the whole of the lower portion of the vessel, the crew's quarters and armaments would be on the upper decks. There would be eight propellers of 9 feet in diameter, revolving at about 400 revolutions per minute, and her speed would be 44 knots. She could carry coal at this speed for about eight hours, and she would be able to steam at from 10 to 14 knots, with a small section of the boilers and supplemental machinery, more economically than other vessels of similar size, and of ordinary type and power, and when required all the boilers could be used, and full power exerted in about half an hour.

In the case of an Atlantic liner or a cruiser of large size, turbine engines would effect a reduction in weight of machinery, and also increased economy in fuel, tending either to a saving in coal on the one hand, or, if preferred, to some increase in speed on the same coal consumption per voyage.

In conclusion, it may be remarked that in the history of engineering progress, the laws of natural selection generally operate in favour of those methods which are characterised by the greater simplicity and greater economy, whether these advantages be great or small.

The work in this undertaking has perhaps been slow, but many difficulties were met with besides those of a mechanical nature, and, as is generally the case, the success so far attained has been largely due to devoted colleagues and staff, and in the marine developments to the enterprising and generous financial assistance.

My thanks are due to the officials of this Institution for the kind assistance they have afforded me in the arrangement of the apparatus.

ADVANCEMENT OF ELECTRICAL CHEMISTRY.

ON reviewing the science of electro-chemistry and its application to modern manufacturing processes, one is struck with amazement at the enormous strides which have been made within the last ten or twenty years. On studying works on chemistry little more than ten years old, hardly a reference is found to the use of electricity in metallurgy, still less in regard to the manufacture of metallic salts, or of the non-metals, and absolutely none in reference to the preparation of organic chemical bodies, at any rate on a large scale.

We are told that in 1808 Sir Humphrey Davy discovered the metals—sodium and potassium—by the electrolysis of their moist hydroxides; we are then informed that they are now manufactured by the much cheaper method of heating the carbonates with charcoal and chalk, or the hydroxides with carbide of iron. To-day we find a retrograde step has been taken, and that they are manufactured by the vastly cheaper method of electrolysing their chlorides or hydroxides.

Notwithstanding that Faraday and others early in the nineteenth century had shown that metals could be deposited, from the solutions of their salts, upon other metals by means of an electric current, and Faraday had, in 1833, formulated his law that "The amount of any substance liberated is proportional to the total quantity of electricity passed through the solution," and that "the amount of different substances liberated by the same quantity of electricity are in the ratio of their chemical equivalents"; electricity until quite recently was not used as an adjunct to chemical analysis. Within the last few years electro-chemical analysis has been very much studied, and now most laboratories *abroad* are fitted with special apparatus for this class of analysis. It is to be feared that in this country we are hardly so advanced.

Within the last thirty years the process for depositing metals from their solutions, and so obtaining moulds for casting, &c., has not undergone any very radical changes, but the means at our disposal for carrying out the work have enormously improved.

Until the advent of the dynamo and the storage battery, methods of electrical analysis or of galvanic deposition could not profitably be employed, at any rate on a very large scale; now, however, with the cheapening of production, very much has been made possible, which but a few years ago would have been scouted as Utopian. Is it realised by those who admire the splendid photographic reproductions which are met with on every hand, even in penny illustrated journals, that the majority of these are reproduced by means of electrical processes? A scene, *e.g.* the leaving of volunteers for the seat of war, is photographed, and in a few hours by means of electrical stereotype is transferred to a metal plate and is ready for the printer.

Those interested in metallurgy knows how difficult it is to obtain absolutely pure copper by furnace methods, even after many processes of refining, the copper still contains small quantities of impurities from which it is only with great difficulty freed. When copper is required for electrical purposes, very small quantities of impurities considerably reduce its conducting power. For this reason then it is important to obtain perfectly pure copper; and as the impurities often consist of gold and silver, endeavours have been made to obtain a process which would produce absolutely pure copper, and at the same time leave the gold and silver in a workable condition. Thanks to electro-chemistry, such a process has been devised and is now very largely used. The copper which has either been cast into plates or bars, or granulated, is placed in a bath of copper sulphate and connected with an electrical machine as the anode, a plate of pure copper forming the kathode. On the current being passed, the copper at the anode dissolves and is deposited on the kathode in the pure condition; the impurities—gold, silver, antimony, arsenic, etc., dissolving in the bath or remaining on the anode as a sponge, finally falling to the bottom of the bath forming a muddy sediment ("anode sludge").

The electrolytic deposition of copper is also made use of in the manufacture of weldless copper tubing. In a bath of copper sulphate, granulated copper is made the anode, the kathode consisting of metallic spindles, the thickness of which is determined by the size of the tube it is desired to produce. The spindle is made to revolve at a very high rate of speed; by this means the copper, which ordinarily is deposited in a more or less crystalline condition, forms a dense and even deposit, which, when used for boiler tubes, &c., is capable of sustaining very high pressures without bursting.

Although it has not up to the present been found practicable to obtain zinc commercially from its ores by electrolytic methods, notwithstanding the many attempts which have been made, it is interesting to note that zinc galvanising by electrolysis is now being used to a very considerable extent, in place of the old method of hot dipping, the zinc, as in the case of the copper deposition just described, being made the anode in a weak acid bath, the material to be galvanised the kathode. The galvanising of the inner surfaces of tubes has always been very difficult; in the electrolytic method the difficulties are overcome. The bottoms of ships, torpedo-boats and other large surfaces are now frequently galvanised by means of the electrical galvanic process.

The advantages which this method has over the hot dipping process are obvious. In the latter, many tons of zinc have to be kept in a state of fusion over long periods, the expense of fuel being very great, and the loss of zinc through alloying and oxidation very considerable. In the old process the tensile strength of the iron and steel is said to be diminished. In the new process it is claimed that the quality is in no way depreciated.

Probably "the man in the street" would point to the manufacture of aluminium as being the triumph of electrical chemistry. Certainly, here is a triumph, and it will perhaps be interesting to briefly trace the development of the industry since the discovery of the metal by Wöhler in 1827. He obtained it as a grey powder by heating aluminium chloride with potassium. In 1856, Bunsen prepared it by electrolysis of the double chloride of sodium and aluminium. Deville, in 1854, obtained it by the action of sodium on this same double chloride, but owing to the high price of sodium, aluminium cost, in 1857, 5*l.* the pound; even in 1888 the price was over 2*l.* per pound. In this year the Netto-Castner process for the manufacture of sodium was perfected, and as a consequence the price of aluminium at once fell to 15*s.* the pound. Shortly after this the electrical methods were employed, and now aluminium may be obtained at less than 2*s.* the pound; the cost would probably be still further reduced if the metal itself were of more general use.

Calcium carbide, which is now being largely manufactured by heating a mixture of limestone and coke in an electrical furnace, has made it possible to obtain, at a small cost, acetylene gas, which, were it not for the restrictions that are placed upon the storage of the carbide, would probably be used to a very much greater extent. The extraordinary brilliancy of the light which this gas gives causes one to wonder that attempts have not been made to employ it for street lighting.

In gold, silver, and nickel-plating, electrolysis on a small scale has been employed for a number of years, and within the last few years it has been successfully used on a large scale for gold extraction. In the McArthur-Forrest cyanide process for obtaining gold from the "tailings," a double cyanide of gold and potassium is obtained; from this double cyanide the gold is precipitated by means of metallic zinc, the gold so obtained having to be refined and purified. By the Siemens-Halske process the cyanide solution is electrolysed by means of weak currents, the gold being deposited in a purer form than when precipitated by means of zinc. In this process the anodes are of iron, and the kathodes on which the gold is deposited of lead; an amalgam of lead and gold being obtained, from which the latter is recovered by cupellation. By this method the gold is obtained purer, and the quantity of cyanide employed is much less than is the case in the original cyanide process. There is little doubt that in a short time a very large percentage of the "tailings," both in Australia and Africa, will be worked by means of electrical processes, and it is not impossible that a process will be devised for the treatment of the auriferous quartz, though, up to date, attempts in this direction have not been commercially successful.

Either with the electric furnace or by electrolysis, it is now possible to obtain practically all the metals from their oxides or salts, *e.g.* chromium, by heating the sesquioxide with aluminium in an electric furnace; magnesium, by electrolysis of fused carnallite; the rare metals yttrium, lanthanum, and cerium have also been isolated by electrolysis of their fused chlorides. An interesting process for purifying tin might be mentioned here. The metal obtained from American sources often contains appreciable quantities of gold. A very neat method for separating the tin from the gold has lately been patented. The gold-containing tin forms the anode in a bath of sodium sulphide, the kathode being a strip of pure tin; on the current being passed, the tin at the anode dissolves, forming a thio salt, from which it is deposited, pure, on the kathode. The gold with other impurities hangs on the anode in a spongy form, or falls to the bottom of the bath, as "anode sludge," from which it is readily extracted.

As showing the many-sided character of electro-chemistry, an interesting process for obtaining accurately reflecting mirrors might be mentioned. Many attempts have been made to prepare perfect metallic mirrors, in which the use of glass could be done away with, and on a small scale for lamps the attempts have been fairly successful; but where a moderately large and true reflecting mirror is required, attempts to substitute cast, spun or stamped metal for glass have always been unsatisfactory. The difficulty seems to have been overcome in a process brought out by Mr. Cowper-Coles. A glass mould is obtained, the convex side of which is accurately shaped and polished to form a true parabolic or other reflecting surface. On the prepared surface a metallic coating of silver is deposited by chemical means; it is then polished, and a backing of copper is deposited to any desired thickness, by making the silver the kathode in a bath of copper sulphate, the mould being at the same time rotated in a horizontal position. The copper adheres firmly to the silver, and as soon as sufficient has been deposited the glass mould is placed in cold water, which is gradually warmed. The unequal expansion of the metal and the glass causes the two to separate, yielding a concave surface of silver on copper, exactly corresponding to the mould, which requires no further polishing. As, however, silver when exposed to atmospheric conditions rapidly tarnishes, metallic palladium is electrolytically deposited on its surface. Palladium is not affected by atmospheric changes, being practically unoxidised even at high temperatures. Its reflecting power, moreover, is but little inferior to that of silver.

A metallic reflector prepared after this method was recently tested at Portsmouth, a number of rifle bullets being fired through it; it was even then found that the beam was but slightly affected. Whereas one shot fired at a glass reflector smashed it to pieces. It is obvious then that such mirrors should be of great value in the Army and Navy, as reflectors for searchlights, where the breaking of the mirror in time of action might have very serious results.

In this article it has only been possible to touch the margin of the electro-chemical industry, and only, with the exception of calcium carbide, such processes as deal with electro-metallurgy and electrolytical deposition have been dwelt upon. It is hoped in another article to draw attention to the production of non-metallic elements, and to the manufacture of chemical products both inorganic and organic.

F. Mollwo Perkin.

THE PROBLEM OF COALING AT SEA.

War, at the present time, brings home to us the necessity of considering "Energy," its different forms, and their practical application. In these days, when the machinery of a battleship not only propels the vessel, but lights, ventilates, and controls the working of the heavy guns, it may be said that the ship is primarily dependent on one source of energy—Coal. A vessel short of this requisite has hitherto been compelled to fall out of line and be thus useless until she has "coaled ship," which in many cases entails several miles steaming, delay, and perhaps lost opportunities.

On this account any efficient mechanical contrivance for overcoming the difficulty of obviating the ship putting into port and enabling a full recharge of energy while cruising to be possible must be looked upon by all with interest.

In the *Engineering Magazine* for February is an illustrated account of a series of trials made in the United States Navy with the "Miller Conveyor" for coaling at sea, and the method may be briefly described as follows:—

The battleship to be coaled tows the collier, from which it takes the coal in loads of 840 lbs. by means of an overhead cable and suspended carriage. During the experiments two points of interest presented themselves: (1) The proper distance between the ships; (2) The way of overcoming the variation required in the length of ropes caused by the rolling and pitching. With regard to the first point it was found that with 300 feet between the ships, the collier would not follow properly, but during the rough weather trial with about 400 feet between the ships, the collier followed perfectly.

The second point caused the chief difficulty, and in Mr. Miller's design we find the length of overhead cables made variable, as required partly by the movement of the ships themselves, and partly by the power engine on deck. In the following table will be found information and data of the five trials made:—

Trial Number	Speed	Number of loads (840 lbs.) or tons transshipped	Remarks
First	5 to 6 knots	9 loads only	Adjustments made
Second		14 tons 5 cwt. in 38m. 40s.	Work stopped through lack of skill on part of operator
Third		22 tons in one hour	Work could have continued but for lack of sufficient crew to fill the bags
		Between the third and	fourth slight alterations made
Fourth		75 tons in 3h. 43m.	Trial lasted four hours; water smooth, ground swell
Fifth		80 trips made in 80m., or 30 tons in 1h. 20m.	Could have continued indefinitely. Board of Judges satisfied. Water rough.

As we are informed that the battleship consumed about 3½ tons of coal per hour, the actual (or rather "paying") rate of coaling obtained was sixteen or seventeen tons.

The behaviour of the apparatus in rough weather was satisfactory, and the author writes, "The boats steered at first head on to the sea, the forecastle of the battleship *Massachusetts* was washed at every plunge, and no coal could have been delivered there, even if desired. The course was then changed quartering on the sea; the results were the same. Then the boats steered in the trough of the sea, and the rolling did not affect the working."

The article, which is illustrated with ten good photographs and a diagram, is certainly worthy of note, and deals with a subject which it is possible will revolutionise naval warfare in the near future.

MERCURY AS A NAKED EYE OBJECT.

Rarely visible, and always difficult to observe satisfactorily in a telescope, this planet is yet a most attractive object to the unaided eye. Not receding to a greater distance than 28° from the sun, he is, however, never above the horizon in England for a longer period than two and a quarter hours before sunrise, or for a similar interval after sunset. When an evening star in the spring months or a morning star in the autumn season, he may often be caught and watched for an hour or so, shining with a sparkling, rosy lustre, and presenting much the same aspect as a fixed star.

To secure a view of Mercury forms one of the earliest and greatest ambitions of the amateur astronomer. Among his first books there will sure to be a copy of Mitchell's "Orbs of Heaven," or Dicks's "Celestial Scenery," and on reading the statement that Copernicus never succeeded in seeing Mercury, he resolves that he will do his best to catch a glimpse of this elusive little "Messenger of the Gods." After some vain attempts he finally succeeds, and it is not too much to say that the spectacle sometimes excites and gratifies the observer more than any other subsequent event in his astronomical career. Who is there among us who does not remember the thrill of pleasure incited by the first detection of this fugitive orb, and the conscious pride with which we realised that we had commenced our celestial work by achieving a feat which had been denied to the greatest astronomer of the sixteenth century?

But, as a matter of fact, there seems to be considerable doubt whether Copernicus ever really complained of failure to see Mercury. There is evidence to show that he never expressed himself in the manner quoted in many of our popular text-books. There may, it is true, have been some ground for the statement, but it is well known that a biographer has only to introduce a special incident of the kind alluded to, or to unduly colour some expression, and whether on doubtful evidence or not, it is liable to be copied and recopied by subsequent writers without any investigation until it becomes generally accepted as a fact. But admitting for the moment that Copernicus really failed to discern Mercury, he seems to have had very good reason for it. His residence was at Thorn, in Prussia, and through the valley near ran the River Vistula, over which were frequent fogs which obliterated objects near the horizon.

This tradition about Copernicus and Mercury has certainly, however, enhanced the interest with which the planet is regarded as a naked eye object. The beautiful white lustre of Venus—incomparably brighter than the aspect of Mercury—the stronger and steadier, yellowish light of Jupiter, or the conspicuous ruddy hue of Mars may present a more striking appearance in the sky than the twilight-veiled splendour of Mercury, but there is something about the sparkling lustre of the latter orb, hovering fugitively on the brow of the horizon, which forms an attraction peculiarly its own.

The best time to observe the planet in 1900 will be during the first eleven days of March, when his times of setting will be as follows:—

		h. m.			h. m.
March	1 ...	7 10	March	7 ...	7 36
	2 ...	7 16		8 ...	7 39
	3 ...	7 21		9 ...	7 41
	4 ...	7 25		10 ...	7 41
	5 ...	7 29		11 ...	7 41
	6 ...	7 33			

During this period Venus will be a very brilliant object, situated about 21 degrees E.N.E. of Mercury. The greatest elongation of the latter (18° 16′ E.) will occur at 11 a.m. on March 8, on which day he sets about 1h. 50m. after the sun. If the western sky is clear on March 2 at about 6 p.m. an exceptionally good opportunity will occur for detecting the planet, for he